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ScienceDirect

Procedia Manufacturing 3 (2015) 1654 – 1659

Procedia MANUFACTURING

6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015) and the Affiliated Conferences, AHFE 2015

Green BIM in sustainable infrastructure

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Abstract

The objective of this paper is to explore BIM (Building Information Modeling) applications in sustainable infrastructures. In response to the global warming, the shortage of energy resources, and the challenges of environmental degradation, humans are trying to build low-carbon Eco-cities and to popularize low-carbon green buildings. Building “green”- refers to the entire life cycle of the building, which includes maximizing the conservation of resources (energy, water, land and materials), protecting the environment, reducing pollution, providing people with healthy, comfortable and efficient use of space, and establishing a harmony of nature and architecture. In the field of green and sustainable buildings, BIM can be integrated in analog-energy buildings, the air flow analysis and buildings’ sunshine ecosystems. By using BIM it is possible to reduce waste and improve construction quality. BIM builds a "visualization" of the digital building models through a multi-dimensional digital design solutions, which provide the "simulation and analysis" of scientific collaboration platforms for designers, architects, utilities engineers, developers and even end users. Moreover, the BIM helps them to take advantage of three-dimensional digital models in design and construction of projects and operational management.

Keywords: Green building; Information modeling

1. Research problem

In implementation process of green designs, sustainable design methods can be used to analyze the impacts of green buildings, including all aspects of lighting, energy efficiency, sustainability of materials and other building performances. It is essential to combine the designs and the constructions of green technology, thus making a design more reasonable and optimized, and finally achieving the accordance with green buildings parameters. At the same time, green buildings measures will also promptly complete expression in the construction design, thereby ensuring that the project results meet the standards of green buildings [2]. In the experimental study, a series of building

doi:10.1016/j.promfg.2015.07.483

Fig. 1. Tent Hotel in Hengshan NaShan Village. Bird eye view.

information models will be created in the process of proposing site design, building design, construction, execution, maintenance, renovation, demolition. For instance, window to wall ratio control, building shape, air distribution, building natural ventilation, natural lighting , design optimization and adjustment based on the results of the analysis, efficient building envelope, vertical greening systems, ground source heat pump coupling solar heat pump systems, water-saving irrigation systems, energy dissipation architecture, renewable and recyclable ways of exploiting materials and other technical measures, analog implementation, solar air conditioning and rainwater harvesting, etc. BIM technology in the design stage of sustainable infrastructure will be made full use of.

2. Research methodology

In the case study, a series of building information models will be created in the project, we will simulate the green buildings and analyze them. The sustainable design methods in BIM will be used to analyze the impacts of green buildings, including all aspects of lighting, energy efficiency, sustainability of materials and other building performance [1]. It is essential to combine the designs and the constructions of green technology, thus making a design more reasonable and optimized, and finally achieving the accordance with green buildings.

2.1. Green BIM with the planning site location and analysis

The site location and analysis are the main factors affecting the position of the buildings. Those factors could determine the spatial orientation and facade of the buildings and contact with the construction process of the surrounding landscape. During the planning process, the site topography, vegetation, and weather conditions are important factors. The traditional site analysis has drawbacks, such as lack of quantitative analysis, excessive subjective factors, incapacity in dealing with prodigious amount of data and information. By taking advantages of BIM and GIS, we could build simulation spatial data modeling sites and scenarios of buildings. At the planning stage, by using BIM to assess site conditions and characteristics, it is feasible to make an ideal key decisions, traffic flow line organizational relationships and building layout.

2.1.1. Project overview

The case study is based on an international design competition of the Tent Hotel. The sites and proposition of the tent-themed hotels, which can adapt to various climates, is convenient to build up, and then form a local cultural flavors and inspire a new style of holidaymaking. The project site is Hengshan NaShan Village in Hengshan scenic area of Hengyang city, which is approximately 130 kilometers away from Changsha city, the capital of Hunan province and is about 150 km from the Huanghua Airport in Hunan province. The village is 4.5 kilometers away from Hengshan city center, and is available within 15 minutes' drive, or 1 hour's walk. In a distance of 12 kilometers to the top of peak ZhuRongFeng, the village is available within 40 minutes' drive or 4 hours' walking. Since 2005, the hotel industry in China have been developing in a high speed, as a consequence of more and more

families' paying their attention to spent lifestyle vacations. However, hotel architecture have a huge impact on the ecological system, especially on a natural environment causing energy consumption, pollution and carbon footprints during and after the construction, which usually have impact on the ecological system, especially on a natural environment. This is a phenomenon which is worthwhile to pay attention to and it is also what the competition is aiming at: to minimize the impact on natural environment. Boundary of the site area is 10ha. Nanshan village is situated in mountainous area with an average elevation of 550 meters.

2.1.2. Design requirements for the "Tent Hotel"

- Mobile: mobile and convenient, with little or no permanent impact on the site.
- Culture: reflecting local cultural elements, providing unique life experiences.
- Eco-friendly: reaching LEED standards, fully embodying sustainable and low-carbon design principles.
- Establishing BIM model to coordinate the designs. Then using BIM software simulation of the model for green building analysis.
- Analysis by simulating daylight, sunlight, shade, sub-environment.

Concluding, BIM can provide the basis for sustainable green building programs and conservation measures based on the results of these analysis.

2.1.3. Site analysis

An AutoCAD Civil 3D® model was used to resolve the planning design [3,4]. The initial modeling was performed by the data, which are: the site location, climate condition, Ecological Value, Site Information, Transport Infrastructure. The AutoCAD Civil 3D® model will be used mainly to generate 3D visualizations. Subsequently, the same model was used by the project's green analysis. From the resource sustainability considerations, we chose flat pieces of land as planning plots. Planning land area of 3 hectares, flat terrain, with pools, tea ladder and streams. Planning plot is located in the south slope of the low height close to the road to the city.

In the design process, numerous options are tested before reaching a conclusion. This allows to fully understand the site and to start a dialogue with the buildings about their green parts.

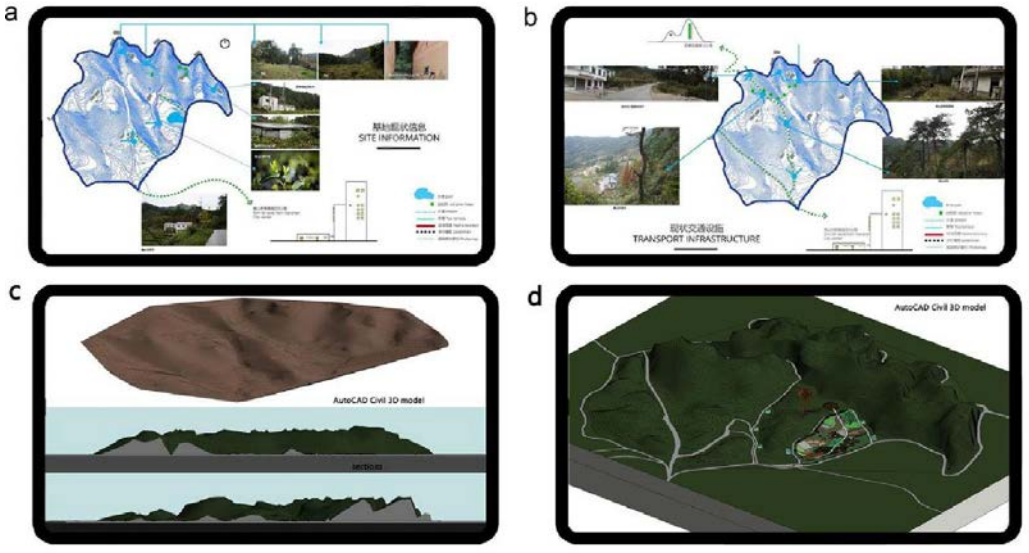

Fig. 2. Tent Hotel in Hengshan NaShan Village. (a) Site information; (b) Transport infrastructure; (c) AutoCAD Civil 3D@ site model and sections; (d) AutoCAD Civil 3D model.

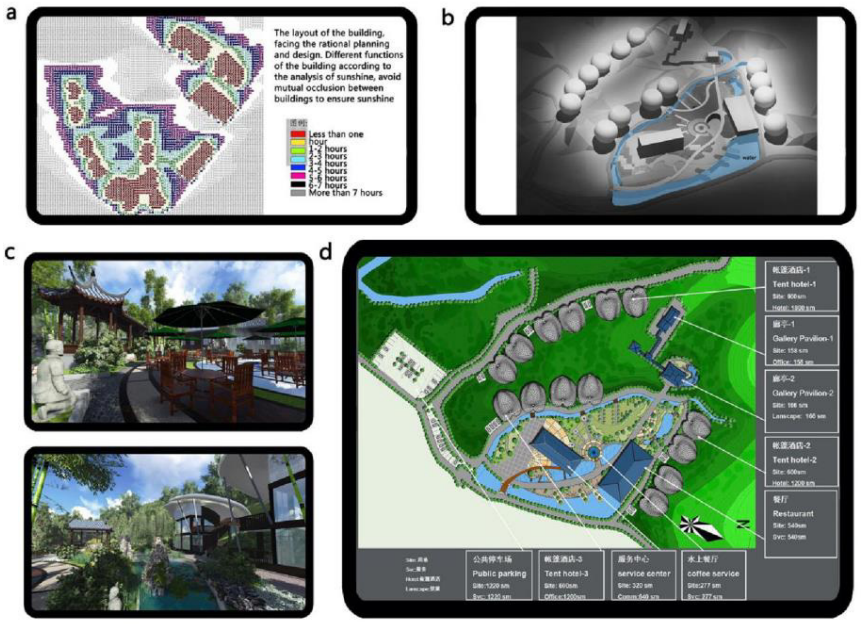

Fig. 3. Tent Hotel in Hengshan NaShan Village. (a) Daylight analysis; (b) 3D models analysis; (c) Simulation renders; (d) Master plan.

2.1.4. Organizational principles for the "Tent Hotel"

- Design of a sustainable development of energy-saving and environmentally friendly features of the Tent Hotel. Creating a great Waterfront Park contributes to the Tent-Hotel Plan.
- Creating three functional zones, each of them touching the Riverfront Park.
- Diverting roads towards water. All the buildings connect the districts to the Riverfront Park. In Chinese garden planning, water is the most important part. "Yard" is traditionally defined as a space surrounded by architecture, which is situated against the mountain and surrounded by water. It is described as "Feng Shui" in Chinese.
- Daylight analysis. The layout of the building, confronted with the rational planning. Different functions of the building are created according to the analysis of sunshine, thus avoiding mutual occlusions between the buildings to guarantee the lighting.
- 3D models analysis. By exploiting analysis, it is more convenient and feasible to assess site conditions and characteristics of a project at the planning stage, thus helping to make an ideal key decisions, planning new projects, traffic flows, line organizational relationships, building layout. After constant adjustment and analysis, the final conclusions are obtained.

2.2. Green BIM with the planning building design and analysis

2.2.1. Building design and analysis

- The use of natural ventilation, natural lighting and shading effective measures.
- The use of solar energy.
- Rainwater recycling and waste recycling.
- The outdoor use of permeable ground.
- The use of green materials.
- Focusing on ecological maintenance.
- The application software featuring of energy-efficient computing; the use of natural ventilation, and performance analysis.

2.2.2. Natural lighting.

In the master planning main facade is directed towards the South, in order to get enough natural light. Building information model allows to find the most reasonable position, installation guide device, the direct light diffusion in the interior space, allowing plenty of natural light indoors, due to diffusion and bright, energy-saving lighting. The solar power generation is integrated with external shading capabilities, in order to exert the double benefit of power generation and energy-saving.

2.2.3. The use of solar energy

The tent's roof is made of solar panels as the outer material. Solar panels will not have a battery and they can be directly connected to the supply the network. During the operation of building, panels can also be deactivated, which means that more power can be saved. The building interior lighting design is mainly based on LED lights. LED lights are powered by solar panels supply.

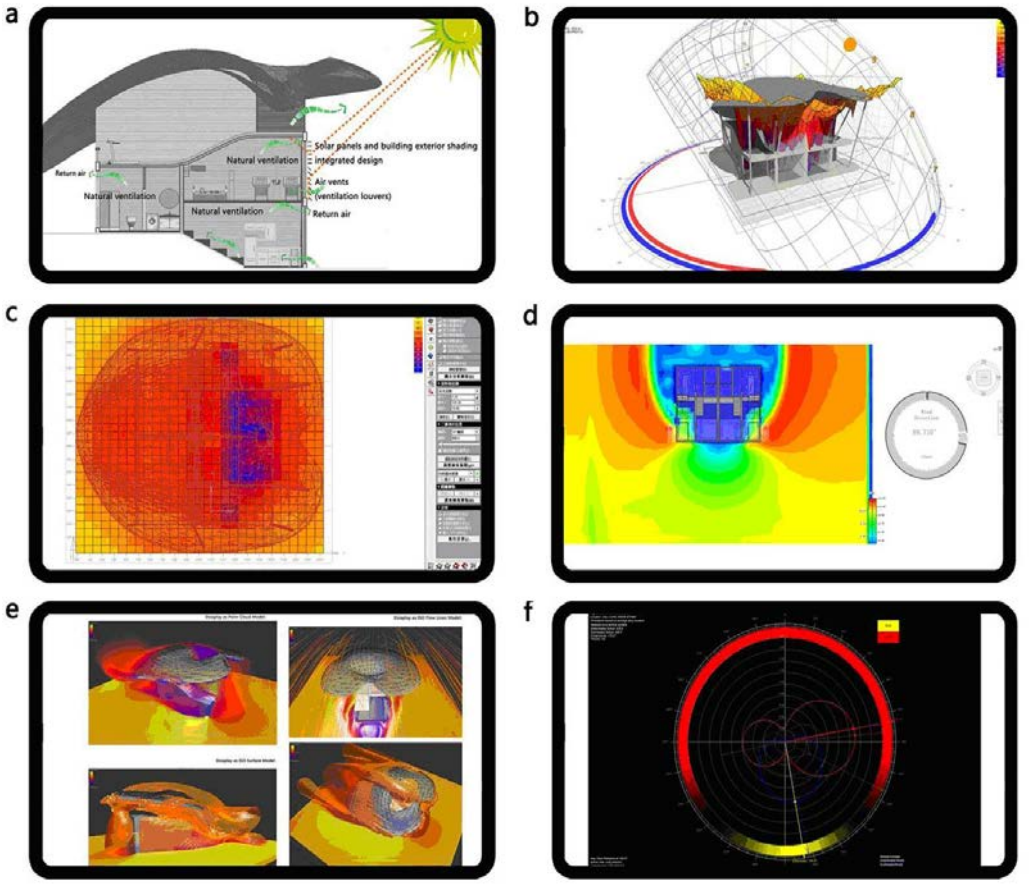

Fig. 4. Tent Hotel in Hengshan NaShan Village. (a) Natural ventilation analysis; (b) Natural lighting; (c) Natural light and lighting; (d) Wind Environment Simulation； (e) Wind analysis; (f) Optimum Orientation.

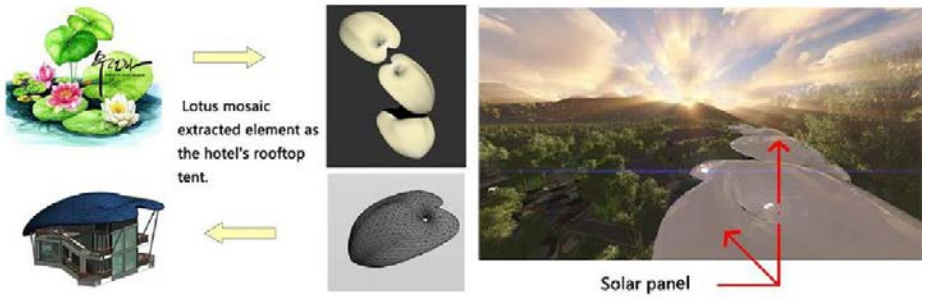

Fig. 5. Tent Hotel in Hengshan NaShan Village. Solar energy analysis.

Fig. 6. Tent Hotel in Hengshan NaShan Village. Water supply analysis.

2.2.4. Rainwater recycling and waste recycling

The tent shape of the roof is used to collect rainwater. The building located at the bottom of rainwater collection system is meant for storing large amounts of rain. Collected rainwater will be used for irrigation or other outdoor plants, as well as energy-saving measures.

3. Conclusion

The presented example shows that the use of BIM (Building Information Modeling) is an effective tool for the integration of natural and technical systems in architectural design.

Multi-dimensional digital model of the Tent Hotel gave the opportunity for efficiency multidisciplinary project coordination, in accordance with the principles of green design.

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